

#### REMARKS

Claims 1-11 are pending in the present application and stand rejected on a variety of grounds. Claim 1 has been amended to clarify the step-wise order of the process. No new matter is added by the amendment. Applicant respectfully requests full consideration of the remarks contained herein.

#### Rejections Under 35 U.S.C. § 102

Claims 1, 3, 4, and 6 were rejected under 35 U.S.C. § 102(a) as being anticipated by Nakamura et al. (Atomic-Layer Deposition of  $\text{SiO}_2$  by Remote Plasma CVD). The Examiner states "Nakamura discloses a method for growing silicon dioxide films in a chamber by sequential chemical vapor deposition using a plurality of cycles comprising the steps of removing gases from the chamber, exposing the substrate to a silicon source, exposing the part coated with the silicon source to plasma comprising atomic hydrogen (abstract)."

Claim 1 has been amended to clarify that the recited steps in the deposition cycle are carried out in order. Thus, the process of Claim 1 includes provision, in order, of a silicon source, followed by a hydrogen source, followed by an oxygen source. Applicants respectfully submit that the process of Nakamura differs from that of Claim 1, as amended, at least in the order of provision of chemical sources. Nakamura teaches provision of a silicon source ( $\text{SiH}_2\text{Cl}_2$ ), followed by an oxygen source ( $\text{N}_2\text{O}$ ), followed by a hydrogen source (H).

The order of pulsing of reactants in Nakamura is important for their process. Applicant notes that hydrogen is used in Nakamura to provide a particular, desired surface termination and does not reduce the silicon reactant prior to oxidation, as in the present claims. Further, the order in which reactants are deposited is significant in Nakamura. Nakamura discloses that the silicon precursor reacts with a hydrogen surface termination and that the hydrogen plasma is supplied last in order to provide a hydrogen surface termination for the next cycle, which begins with provision of the silicon precursor. Changing the order of provision of the reactants would thus be incompatible with Nakamura's disclosed process.

Moreover, Nakamura reports problems with hydrogen plasma etching causing sub-monolayer rates of deposition and states that "In future research, optimization of hydrogen plasma processing conditions will likely be important." That Nakamura suggests further

optimization in the provision of hydrogen is necessary, without suggesting changing the pulsing order, indicates that the order in which hydrogen is provisioned is not trivial.

As Nakamura does not teach or suggest all of the features of the pending claims, Applicant respectfully requests withdrawal of the rejection of Claims 1, 3, 4 and 6 under 35 U.S.C. §102.

### **Rejections Under 35 U.S.C. § 103**

#### **A. Claims 1-7**

Claims 1-7 were again rejected under 35 U.S.C. § 103(a) as being unpatentable over Sandaresan (U.S. 6,064,077) in view of Bedair (Atomic Layer Epitaxy Deposition Processes) and further in view of Faraone *et al.* (U.S. 4,604,304) or Molsa (Deposition of Cerium Dioxide) and Faraone *et al.*

In a previous response, Applicant argued the following:

The primary references (Sandaresan and Bedair) are both concerned with *epitaxial* deposition of silicon and indeed that is why the Examiner combines them. Sandaresan is cited for depositing an epitaxial silicon layer and then oxidizing a portion, while Bedair is cited for teaching a plasma ALD process for depositing epitaxial silicon. The Examiner essentially argues that Faraone suggests depositing the oxide portion of the layer in Sandaresan monolayer by monolayer. However, once the first monolayer of oxide is formed, it would not be possible to deposit another epitaxial layer of silicon. Thus, in subsequent cycles epitaxial deposition of silicon *can not be achieved*. Because Bedair is concerned with *epitaxial* deposition of silicon, one of skill in the art would not consider using the process of Bedair in a *non-epitaxial* deposition context. In other words, Bedair would not be able to achieve their goals of epitaxial deposition if each silicon layer were oxidized prior to deposition of the next silicon layer and, importantly, there would be no reason to use the plasma atomic layer epitaxy process of Bedair in such a process. As a result, one of skill in the art would not be motivated to use the plasma ALD process in any cyclical process for depositing silicon and oxidizing.

The Examiner labels this argument as “mere conjecture” unsupported by factual evidence. Applicants note that Morishita, p. 1, c. 1, states that SiO<sub>2</sub> films are amorphous and, therefore, by definition lack a long-range crystallographic ordering: “...SiO<sub>2</sub> film is amorphous and therefore its monolayer thickness cannot be defined precisely...” [emphasis added].

The Examiner cites Molsa for the proposition that some oxide films may be grown epitaxially via atomic layer deposition. However, Molsa refers specifically to oxides which may grow in a fluorite-type crystal structure. Molsa does not state that SiO<sub>2</sub> is fluorite-type; indeed Molsa implies the very opposite. Molsa notes that CeO<sub>2</sub> is an especially promising oxide for deposition on silicon because it and other *fluorite-type* oxides “have been reported to grow epitaxially on silicon without twinning.” Consistent with the teaching in Morishita, the implication in Molsa is that non-fluorite type oxides, especially those to which CeO<sub>2</sub> is being compared (such as SiO<sub>2</sub>), have not been reported to grow epitaxially.

The Examiner next suggests that “even in the event that [silicon dioxide is amorphous and thereby not amenable to epitaxial growth,] a portion of the layer of Sandaresan is silicon dioxide and therefore, the references would suggest depositing multiple layers of oxidize[d] silicon is within the skill of those ordinary in the art.” Applicant respectfully submits that Sandaresan teaches an amorphous oxide layer on top of an epitaxial silicon layer. Sandaresan is not concerned with deposition of multiple layers of SiO<sub>2</sub>. Rather Sandaresan is concerned with deposition of single epitaxial layers of Si and subsequent oxidation of a portion of the single layer. Single-layer epitaxial deposition and deposition of amorphous films are distinct, and one reasonably skilled in the art would not be motivated to combine teachings related to epitaxial deposition with teachings related to deposition of amorphous films, much less have a reasonable expectation of success in doing so.

Moreover, one skilled in the art would not be motivated to apply the teaching of the secondary references to Sandaresan since the Sandaresan process itself requires epitaxial silicon growth. As discussed above, such epitaxial growth is not possible on amorphous silicon oxide films.

Lastly, the Examiner states that “Bedair discloses known and suitable method[s] for deposition and the selection of something based on its known suitability for its intended use has been held to support a prima facie case of obviousness.” The intended use of the Bedair process

is *epitaxial deposition*. Thus, Bedair can only be selected based on its known suitability for its intended use: epitaxial deposition. This, in fact, is what the Examiner has done by combining Bedair with Sandaresan, a reference that is also concerned with epitaxial deposition. However, because Bedair is not concerned with non-epitaxial deposition, it is not known to be suitable for non-epitaxial deposition and can not be combined with Faraone (in which epitaxial deposition is not carried out). As noted in Applicant's previous response, the combination would destroy the reason for the combination of Bedair and Sandaresan, namely epitaxial deposition. Thus, even if Bedair's intended purpose may be fairly characterized as mere deposition, as the Examiner suggests, Bedair must be still be combined with Sandaresan, and the intended purpose of Sandaresan may not be fairly characterized beyond epitaxial growth. As such, one skilled in the art would not be motivated to combine Sandaresan with Bedair to deposit an amorphous film as taught in Faraone, no matter how the intended use of Sandaresan is characterized.

As such and as argued previously, neither Bedair nor Sandaresan may be modified to deposit amorphous SiO<sub>2</sub> monolayers, since such deposition frustrates the purposes of Bedair and Sandaresan, namely, to produce a layer by epitaxial silicon growth. Moreover, even if Sandaresan may be so modified, one of skill in the art would not be inclined to combine the modified Sandaresan (thereby directed at amorphous growth) with Bedair (directed at epitaxial growth).

Claim 2 recites a substrate temperature of less than 300°C. Applicants note that none of Bedair, Sandaresan, Faraone, and Molsa disclose or teach a substrate temperature less than 300°C. With regard to Claim 5, Bedair, Sandaresan, Faraone, and Molsa, singly or in combination, do not teach or suggest the use of tetraethoxysilane. Although not touched on directly, Applicant submits that the remaining dependent claims contain additional patentable features.

As such, Applicant submits that obviousness has not been established and requests withdrawal of the rejection.

#### **B. Claims 8-11**

Claims 8-11 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Nakamura in view of Morishita and Thomas et al. (WO 93/24243). The Examiner argues that it

would have been obvious to a person of ordinary skill in the art to modify the process of Nakamura to use the precursors taught by Morishita and Thomas.

Nakamura is a three-step ALD process involving three reactants, including  $N_2O$  plasma which is used to oxidize the silicon reactant and hydrogen plasma which is used to produce a hydrogen surface termination. Morishita, on the other hand, is a two-step process involving only two reactants, neither of which is a plasma, and does not require a separate surface preparation step. Importantly, Morishita describes at length the superior reaction kinetics of isocyanates with hydroxyl-terminated surfaces. The process of Nakamura, however, involves intentionally forming a hydrogen-terminated surface by treating the substrate with hydrogen plasma prior to introducing the silicon reactant. As this hydrogen termination step is not necessary with the reactants of Morishita, there is no reason for one of skill in the art to substitute the silicon reactants of Morishita into the process of Nakamura.

Moreover, Morishita is directed towards the use of isocyanates as the silicon reactant and, at page 67, indicates that these particular reactants are easily oxidized. Thus, there would be no reason for the skilled artisan to use these reactants in a process utilizing plasma to oxidize the silicon reactant, such as that of Nakamura. This is especially true in view of the disclosure in Nakamura that there are problems with etching associated with the use of plasma. That is, because the isocyanates of Morishita can be used in reactions that avoid plasma etching while achieving a good deposition rate, there would be no reason for the skilled artisan to use them in the process of Nakamura, which has problems with etching. Further, the process of Morishita uses ozone and thus avoids the use of water, one of the primary concerns of Nakamura. Thus, the skilled artisan would have no reason to use the isocyanates of Morishita in the process of Nakamura.

With respect to the asserted combination of Nakamura and Thomas, Applicant respectfully notes that Thomas is directed towards chemical vapor deposition, wherein oxygen is delivered to the reaction chamber simultaneously with the silicon precursor. One of reasonable skill in the art would not be motivated to use CVD precursors in ALD processes and would not have a reasonable expectation of success in doing so.

It is well known in the art that CVD and ALD are very different deposition processes that work on entirely different principles. For example, the skilled artisan would understand that in

CVD processes, unlike ALD, *reactants are decomposed* for deposition. In contrast, ALD involves depositing a layer upon a substrate through alternating, self-limited and saturating surface reactions in which *decomposition of reactants is necessarily avoided* in order to achieve the self-limiting surface reactions. Precursors used in CVD reactions do not need to chemisorb in a self-limiting manner on the substrate, and thus do not need to have the particular physical properties of ALD reactants.

Based on these fundamental differences between the two processes, the skilled artisan would not believe that CVD precursors can always be used in ALD processes, and accordingly would not have considered combining the CVD precursor of Thomas with the ALD methods of Nakamura (which uses halide precursors), much less have an expectation of success in the combination. As discussed above, Nakamura teaches that the silicon halide precursors react with the hydrogen termination on the substrate surface. There is no reaching or suggestion in any of the references that the organic precursors taught by Thomas would react with such a surface termination.

According to MPEP § 2143.02, the references must provide some expectation of success in the claimed combination to sustain an obviousness rejection. *See also In re Dow Chemical Co.*, 5 U.S.P.Q.2d 1529, 1530 (Fed. Cir. 1988) ("Both a suggestion [to combine] and the expectation of success must, be found in the prior art, not in the applicant's disclosure"). Applicants submit that there is no teaching in the cited references that would provide the skilled artisan with any expectation of success in combining Thomas' disclosure of organic silicon precursors for CVD with the ALD processes of Nakamura in any of the references.

The Examiner appears to imply that the skilled artisan would have assumed that any CVD precursor would automatically be useful for ALD. Applicants strongly disagree. While some CVD precursors have surprisingly proven successful in ALD, Applicants submit that CVD precursors are not automatically useful for ALD such that the skilled artisan would have *expected success*. In support of this position, Applicants attach herewith an article by Leskela et al. ("ALD precursor chemistry: Evolution and future challenges") which specifically teaches that reaction properties required of ALD are different from those of CVD such that the *selection of precursors would not be the same* for both processes. (*See, e.g.*, Pr8-839). Indeed, the first line in the Abstract states: "*The requirements of ALD precursors differ from those of CVD* concerning

thermal stability, adsorption on the surface, and reactions towards each other.” (Abstract, emphasis added).

Thus, Applicant submits that it was well known that the requirements and selection of precursors would be *very different for the two processes*, and that the skilled artisan would *not have assumed success* using CVD precursors in ALD processes. Again, there is no showing anywhere in the references that using the CVD precursor disclosed in Thomas would have the necessary properties to be used successfully in the ALD processes of Nakamura.

Claims 8-11 were also rejected under 35 U.S.C. § 103(a) as being unpatentable over Bedair in view of Morishita and further in view of Molsa and Faraone *et al.* (U.S. Patent No. 4,604,304) in further view of Nakamura. The Examiner states that “Nakamura discloses that NO<sub>2</sub> plasma, which as discussed above comprises atomic oxygen[,], has advantages over using H<sub>2</sub>O because water is ill advised for vacuum processes due to the moisture on the chamber walls.” Bedair, however, uses H<sub>2</sub> (and atomic hydrogen) *not* H<sub>2</sub>O. [Bedair, p 184, c. 2] As such, there is no reason to modify Bedair in light of Nakamura, since Nakamura is directed towards solving a problem (namely, H<sub>2</sub>O condensation) that does not occur in Bedair. In addition, as Applicant has pointed out previously, Bedair teaches use of hydrogen radicals only for epitaxial deposition of semiconductor materials. As will be appreciated by skilled artisans, this context has particular needs in order to achieve crystal alignment and thermal limitations. There is no reason in the cited art to apply the teachings of Bedair outside the semiconductor epitaxy environment. In particular, Bedair teaches that hydrogen radicals could reduce deposition temperatures from 815-890°C down to about 600°C for his processes. See Bedair at page 183. As Morishita’s process is already conducted well below 600°C, in fact at room temperature, the skilled artisan had no motivation to attempt to further lower temperatures by use of Bedair’s process. See Morishita at page 68. Therefore, one skilled in the art would not be motivated to combine the references.

Claim 9 recites a first reactant of tetraethoxysilane. Bedair, Morishita, Molsa, and Faraone, singly or in combination, do not teach or suggest the use of tetraethoxysilane. Morishita, for instance, teaches the use of isocyanates.

Accordingly, Applicants respectfully submit that the pending claims are allowable over the art of record. Furthermore, any remarks in support of patentability of one claim should not be

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imputed to any other claim, and any remarks based on a portion of a claim should not be taken as founding patentability on that portion. Rather, it is intended that patentability rests on the claim as a whole. Furthermore, any such remarks which do not quote the claim portion verbatim should not be used to vary the meaning of the claim, as such are intended as a convenience to improve readability. If not specifically addressed herein, Applicants respectfully traverses each of the Examiner's rejections and assertions as to what the prior art shows or teaches, alone or in combination.

Moreover, although the present communication includes alterations to the application or claims, or characterizations of claim scope or referenced art, the Applicants are not conceding in this application that previously pending claims are not patentable over the cited references. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application. The Applicants reserve the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including subject matter found to be specifically disclaimed herein or by any prior prosecution. Accordingly, reviewers of this or any parent, child or related prosecution history shall not reasonably infer that the Applicants have made any disclaimers or disavowals of any subject matter supported by the present application.



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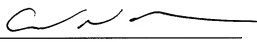
**CONCLUSION**

In view of the foregoing, Applicant submits that the application is in condition for allowance and respectfully request the same. If any issue remains which the Examiner feels may be addressed by Examiner's amendment, the Examiner is cordially invited to call the undersigned for authorization.

Respectfully submitted,

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